MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

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DR. J. W. L. GLAISHER, F.R.S., PRESIDENT, in the Chair;

The Rev. Richard Coad Pryor, M.A., The Rectory, Grafton Regis, Stony Stratford,

was balloted for and duly elected a Fellow of the Society.

The following Candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

Francis William Crook, B.A., Barrister-at-Law, Secretary to the Technical Education Committee of the Kent County Council, 4 Overcliff, Gravesend (proposed by Sir D. L. Salomons);

Frank Lowman, B.A., Lecturer in Science, &c., St. John's College, Battersea, S.W. (proposed by A. E. Moore); and

Charles Nielsen, 15 Cliff Terrace, Hartlepool (proposed by Sir R. S. Ball).

Eighty-eight presents were announced as having been received since the last meeting, including amongst others :—

Eighty-nine charts of the Astrographic Chart of the Heavens, from photographs made at the Observatories of Algiers, Paris, and Toulouse, presented by the French Government; collection

of about 20,000 titles of astronomical works made by the late Mr. G. J. Symons, presented by his executors; The Cape Photographic Durchmusterung, part 3, and Researches on Stellar Parallax, presented by the Royal Observatory, Cape of Good Hope; Sir W. Hamilton, Elements of Quaternions, vol. ii., second edition, edited by C. J. Joly, presented by the Editor; Photograph of the Solar Eclipse of May 1900, by Professor E. E. Barnard, presented by Professor Barnard and Mr. Ritchey; photograph of the cluster in *Hercules* and of a portion of the Moon, made with the 40-inch telescope of the Yerkes Observatory, presented by Professor G. E. Hale; a siderostat by Hilger, presented by Mr. Alex. Foote.

Second Note on Photographs of the Spectrum of Nova Persei; Correspondence with the Spectrum of η Argûs. By F. McClean, LL.D., F.R.S.

The complete list of photographs of the spectrum of *Nova Persei* obtained by me between February 25 and April 9 is as follows. The magnitudes were approximately estimated from neighbouring stars :—

1901.	Mag.		1901.	Mag.	
Feb. 25	1	visual spectrum observed	March 18	4	2 photographs
27	1¼	2 photographs	22	4½	1 „
28	1½	2 „	24	5	2 „
March 1	2	3 „	27	4¼	2 „
2	2	1 „	31	4½	1 „
3	2½	3 „	April 1	4¼	nil „
5	2½	1 „	4	4½	1 „
6	3¼	1 „	5	4½	2 „
9	4	3 „	7	5½	1 „
12	4½	2 „	8	4¼	nil „
			9	4½	1 „

Making in all 31 photographs taken on 18 nights.

These photographs have been enlarged for comparison. Four of them have been selected and mounted together with an approximate scale of wave lengths (plate No. 1, shown at Meeting).

These were taken on the following dates: February 27, March 3 and 12, and April 5. The hydrogen absorption lines were clearly shown on the photographs up to March 18. On March 22 and subsequently they could not be distinguished.

Lantern slides of the same four spectra were also shown. The two earlier ones show the extent of the spectrum photographed from (Hι) to near (D).

The spectra shown by me on March 8 were accompanied by a comparison spectrum of β *Crucis* in order to show the apparent absence of the Helium lines. They were also accompanied by a comparison spectrum of *Sirius* to show the strong similarity between that spectrum and the spectrum of *Nova*. I have now also mounted the spectrum of α *Cygni* for comparison with *Nova*. It is a star of the *Sirian* type, with some exceptionally strong lines. It had already been compared by me with *Nova*, and I revert to it on account of the further resemblance it bears to the bright line spectrum of η *Argûs*.

The spectrum of η *Argûs* was sent me by Sir David Gill from the Cape Observatory in January 1899. He then wrote: "I am sending you by this mail a prism picture of the neighbourhood of η *Argûs*, exposure one hour. The wonderful spectrum near the centre of the field is that of η *Argûs*. There are lots of other bright-line spectra on the plate, as Pickering has already mentioned, but he has apparently no notion what a spectrum η *Argûs* has." This plate was shown in the lantern.

The spectrum of η *Argûs* was enlarged about ten and a half times to the same scale as other enlargements of stellar spectra, so as to be able to compare it with them. On recently comparing it with the spectrum of *Nova Persei*, I found a close correspondence between the bright-line spectrum of η *Argûs* and the absorption spectrum of *Nova Persei*. This correspondence is especially marked from Hγ to Hβ, and the correspondence holds good with the absorption spectrum of α *Cygni*. These three spectra have been mounted together for comparison (plate No. 2 shown at the meeting), and a scale of wave lengths is attached to them.

The absorption spectrum of *Nova Aurigæ* has been plotted to the same scale from the photographs published by Campbell (*Astronomy and Astrophysics*, 1892) and by Frost (*Astronomical Spectroscopy*, 1894). It corresponds closely with the absorption spectrum of *Nova Persei*, and goes to establish the fact that that absorption spectrum is genuine, and not the mere effect of contrast in the spaces between the bright bands. Except the hydrogen bands, the bright line spectrum of *Nova Persei* is difficult to distinguish. To some extent it appears to duplicate the absorption bands, as with *Nova Aurigæ*, and to form a background on which the absorption spectrum is visible.

The spectra of *Nova Normæ* and *Nova Aurigæ* have been compared by Pickering (*Annals of Harvard Observatory*, vol. 26) and found to be "almost identical." It thus appears that the absorption spectra of the three *Novæ*—viz. *Nova Persei*, *Nova Normæ*, and *Nova Aurigæ*—correspond closely with the bright line spectrum of η *Argûs*. It seems possible that the *Novæ* may owe their passing brilliancy to circumstances similar to those

which give rise to the variable brilliancy of η *Argûs*, although, of course, this is only conjectural.

The correspondence with α *Cygni* furnishes an indication of the origin of these spectra. The spectrum of α *Cygni* differs from that of *Sirius* mainly in the strength of its lines. I have previously (*Comparative Spectra of Stars*, *Phil. Trans.*, vol. 191) attributed the characteristic lines of the Sirian stars to "calcium and titanium rather than to iron, although that spectrum is also present in an incipient form."

April 12, 1901.

Addendum.

Additional photographs of spectrum of *Nova Persei* :—

1901.	Mag.	Photographs	1901.	Mag.	Photograph
April 17	$5\frac{1}{4}$	nil	April 21	6	1
18	$4\frac{1}{4}$	2	22	6	nil
20	6	1	27	$4\frac{3}{4}$	1

April 28, 1901.

The Spectrum of Nova Persei. Note 2.
By Rev. W. Sidgreaves.

The bright hydrogen bands have preserved their general character of strength and breadth throughout the month of March and up to April 4, the date of the last photograph. At the beginning and end of March they were well marked by fine central reversals ; in the middle of March they were crossed by two, and in some cases three, lines of greater brightness ; and on April 4 Hζ showed a line of very pronounced maximum strength to the violet side of its wave-length centre.

The dark hydrogen lines showed their comparatively narrow width on March 7, when the bright bands had paled enough to unmask the red side margins of their dark companions. On March 12 the dark lines were well defined doubles, with the violet side components weaker. On the 21st and 22nd the weaker components were lost, and the series became one of very fine single lines. After the 22nd no sign of the dark series has appeared on the plates.

The relative displacement of the two series is very great ; and, apart from direct comparison with the hydrogen tube, it is possible to say, with great probability, that the source of the hydrogen bright bands is comparatively stationary, and that the source of the dark lines, if their displacements are to be

attributed to motion, must be at a velocity far too great for any assignable physical cause. The measured lengths from Hβ to Hγ, to Hδ, to Hε, to Hζ, and to Hη centre to centres of the bright bands, guided by the reversals, are the same as the lengths measured on the spectra of comparison stars; and the measured lengths of the same intervals in the dark line series proceed with an increasing difference, showing a longer spectrum. These differences will be given in wave-length measure in a future full report of the observations of the new star; and they will probably be found to need velocity of the order 10^3 miles to account for them by motion in the line of sight.

Stonyhurst College Observatory:
1901 *April* 7.

The Spectrum of Nova Persei. Note 3.

By Rev. W. Sidgreaves.

Nova Persei as a Variable Star with a Variable Spectrum.

On March 22 it was first seen that there was a marked change in the spectrum when the star was very small, about equal to *l Persei*. A prominent bright yellow band appeared to rival Hα; and on the photograph one of the bright blue bands stood out boldly on the weak continuous spectrum as strong as Hβ, accompanied by three other weaker bands; and, thirdly, the bright Hζ band was extended on the violet side to double its usual width.

On March 25 and 28 the bright yellow band was the same, and the photographed spectrum was the same as on the 22nd; while the photographed spectrum of the 27th was of the same type as on the 21st and previous days: the blue bands were more masked by the stronger continuous spectrum, and Hζ was at its usual breadth. A reference to the journal of observations showed that the three dates, 22nd, 25th, 28th, were probably well marked minima of the star's light curve; and although there was only the one photograph of the spectrum on an intervening day, when the star was brighter, the yellow band had been observed through breaks in the clouds on the 24th and 26th, and was noted as not so prominent as on the three nights of minimum brightness. Since then no photograph has been obtained on a date of minimum magnitude, supposing the period to be three days; but a good photograph on April 4, when the star appeared very nearly equal to κ *Persei*, showed the same spectrum as on the 27th, and the yellow band was noted as weak.

There can be no doubt about the variations of the star's magnitude and of its continuous spectrum; these go together;

and the prominence of the yellow and blue bands at the minimum epoch is in the main the result of the greater contrast on a darker ground. But this does not appear to be enough to account for the strength of the brightest of the blue bands, and fails completely to explain the great extension of the bright H_γ band.

Whatever, therefore, be the cause of dimming the white light of the star at its minimum brightness, it does not in proportion stop its gaseous radiation.

Stonyhurst College Observatory: 1901 April 7.

Observations of the New Star in Perseus made at the Radcliffe Observatory, Oxford.

(*Communicated by Arthur A. Rambaut, M.A., Sc.D., F.R.S., Radcliffe Observer.*)

This paper is a continuation of one published in the last number of the *Monthly Notices* (pp. 348–354). It contains the results of the observations of the brightness of *Nova Persei* made at the Radcliffe Observatory since the date of the last meeting of the Society.

The estimates of brightness have been made as described in the previous paper, but the comparison stars used in these observations are situated in the immediate neighbourhood of the Nova, being all contained within the constellation Perseus. In making the comparisons, as the brightness of the star diminished, recourse was had from time to time to telescopic aid with apertures of from $1\frac{3}{4}$ in. to 10 in., as indicated in the notes.

In Table I. below are given a number for reference, the names of the stars used, and the Harvard magnitudes on which our estimates are based.

Table II. contains the means of each observer's separate comparisons and the general mean for each night.

The results of our observations made since the discovery of the star are graphically represented in the accompanying figure. This diagram exhibits very clearly the variation in the brightness of the star noticed by von Glasenapp and Dunér, and corroborates the period of three days found by them. Thus we have four successive minima taking place on March 22, 25, 28, and 31, and after a cloudy interval we have two more on April 6 or 7 and 10.

A comparison of the notes on the colour of the star with the variation in its brightness seems to indicate some relation between these two phenomena, and suggests that a diminution of light is accompanied by an increase in the redness of the

star. Thus on March 21, when the star was near one of its maxima, the light is described as having "a stronger yellow tinge than when last seen." On March 25, one of the minima, the Nova is noted as "very red to-night." At the next maximum,

Magnitudes of *Nova Persei.*

March 26, the colour is described as "red with yellowish tinge." It must be admitted, however, that the observations of March 27 and 28 hardly support this view, but, on the other hand, those of March 30, April 8, and April 10 point in the same direction.

TABLE I.

List of Stars used for Comparison with Nova Persei.

Ref. No.	Name of Star.	Harvard Photom. Mag.	Ref. No.	Name of Star.	Harvard Photom. Mag.
29	ϵ Persei	3·04	45	ι Persei	4·14
30	γ Persei	3·11	46	θ Persei	4·24
31	δ Persei	3·18	47	ψ Persei	4·24
37	η Persei	3·93	48	σ Persei	4·39
38	ζ Persei	3·10	49	λ Persei	4·54
39	ρ Persei (Var.)	3·68	50	l Persei	4·84
40	κ Persei	3·95	51	31 Persei	4·99
41	τ Persei	3·97	52	30 Persei	5·37
42	ν Persei	4·00	53	36 Persei	5·40
43	o Persei	4·01	54	Arg. Z + 44°, 734	6·04
44	ξ Persei	4·06	55	Arg. Z + 44°, 648	6·47

[(Revision of D.M.)

TABLE II.

Means of Estimations of Magnitude of Nova Persei.

1901	G.M.T. h m	Observer.	Reference Stars.	Mean Mags.	Adopted Magnitude for the Night.
Mar. 8	8 30	R.	29, 31	3·10	3·10
9	8 53	R.	42, 29, 40, 42, 29, 31	3·62	
	9 5	W.	31, 30, 42, 37	3·57	
	9 25	A.A.R.	30, 29, 38, 42, 39, 40, 43, 44, 45, 46	3·65	3·61
	10 30	C.	31, 29, 42, 40, 30	3·56	
10	8 7	W.	30	3·10	
	9 0	R.	40, 42	3·70	3·60
	10 0	C.	31, 29, 40, 42	3·68	
11	10 45	R.	42, 40	3·93	3·93
12	10 45	R.	31, 29, 42	3·87	3·87
13	7 45	R.	45, 42, 40	4·03	4·03
16	8 28	R.	45, 42, 40, 46, 31	3·98	3·83
	9 0	W.	37, 30, 42, 40	3·63	
18	11 0	R.	40, 42	4·00	4·00
20	9 0	R.	42, 40, 31, 30, 46	3·74	3·74
21	7 45	C.	42, 40, 31, 30	3·65	
	7 50	W.	42, 40, 37, 41	4·03	
	8 20	W.	41,* 37,* 40,* 42*	4·03	
	8 35	R.	42, 40	3·70	3·91
	10 45	C.	31, 29, 30, 42, 40	3·94	
	11 0	R.	42, 40, 45, 46	4·00	
22	7 50	R.	50	5·20	5·20
23	8 0	R.	42, 40, 42, 31, 31	3·72	3·92
	8 15	C.	42, 40	4·20	
24	8 30	R.	42, 40	4·20	4·20

* Stars used for telescopic comparisons.

1901	G.M.T. h m	Observer.	Reference Stars.	Mean Mags.	Adopted Magnitude for the Night.
Mar. 25	7 55	R.	50, 52	5·15	5·15
	9 0	C.	—	5	
26	8 35	R.	40, 42, 50	4·20	4·12
	9 45	C.	40, 42	4·20	
	11 20	W.	42, 37, 42*	4·03	
27	7 40	R.	42, 40	3·95	3·98
	8 30	W.	37, 41, 40, 42	3·98	
	8 40	W.	42,* 40,* 37*	3·80	
	10 30	R.	42, 40	4·15	
	12 0	R.	40, 42	4·15	
28	8 15	W.	47, 48	4·30	4·61
	8 15	R.	50, 42, 40	4·73	
	8 30	C.	40, 50	4·60	
	8 50	W.	47, 48	4·55	
	9 0	R.	50, 42, 40	4·83	
	9 10	W.	42,* 40,* 47,* 48,* 51*	4·48	
30	6 30	R.	42,* 40*	4·15	4·14
	8 30	W.	42, 40, 48, 47	4·18	
	9 0	C.	42, 40	4·20	
	9 0	R.	42, 40	4·15	
	9 47	R.	42, 40, 45, 46	4·00	
	10 36	R.	42, 40	4·20	
	11 30	R.	42, 40	4·20	
31	8 30	R.	42, 40, 50	4·40	4·40
Apr. 1	7 30	R.	42,* 40*	4·00	4·19
	8 0	R.	42, 40, 45, 46	4·18	
	12 9	R.	42, 40	4·30	
	12 24	R.	42, 40	4·20	
4	8 15	R.	42, 40, 45, 46	4·08	4·08

1901	G.M.T. h m	Observer.	Reference Stars.	Mean Mags.	Adopted Magnitude for the Night.
Apr. 5	8 35	R.	42,* 40,* 50,* 52*	4·28	4·28
6	9 45	C.	54,* 50*	5·60	5·60
7	8 40	R.	52, 54, 50	5·60	5 60
8	9 30	R.	42, 40, 50	4·43	
	9 45	W.	42, 40, 47, 48, 40,* 50*	4·36	4·40
	10 15	C.	42, 40, 50	4·50	
9	8 30	R.	42, 40, 50	4·50	
	10 15	W.	48, 50	4·60	4·57
	10 15	C.	42, 40, 50	4·63	
10	8 15	W.	47,* 48,* 42*, 40*, 50*, 52*	5·17	
	9 10	R.	53, 54, 30	5·47	5 33
	9 45	C.	50*	5·34	

Observers' Notes on the Estimations of Magnitudes.

March 10. Clouds passing, hazy (W.) Cloud and mist; observation rough (R). Misty. $\frac{1}{2}$ wt. to 40 and 42 (C.)

March 11. Very misty. $\frac{1}{2}$ wt. to 40.

March 12. Cloud and mist at times.

March 18. Rather doubtful. Clouds passing.

March 21. Nova fluctuates in brightness (C.) At $11^h\ 0^m$ Nova sensibly fainter than at 8.35 (R.)

March 22. Observed in breaks of cloud.

March 23. Observed in transient break (C.)

March 24. Observed in breaks of cloud and haze.

March 26. Nova at times momentarily equal to 40 and 42 (C.)

March 27. Nova at $12^h\ 0^m$ fainter, I think, than at $7^h\ 40^m$ (R.)

March 28. 42 brighter than 40 to-night (C.) Bright moonlight. Images sharp in the $1\frac{3}{4}$-inch (W.)

March 30. Daylight observation at $6^h\ 30^m$ (R.) Cloudy; $\frac{1}{4}$ wt. to 48; $\frac{1}{2}$ wt. to 47 (W.)

April 5. Sky hazy.

April 6. Hurried observation in brief but clear interval.

April 7. Very clear for a short interval.

April 8. $\frac{1}{2}$ wt. to 50* (W.)

April 9. Nova estimated as 0·2 fainter than last night at the same G.M.T. (W.)

General Note.—In the above comparisons it was noted that 42 (ν Persei) and 40 (κ Persei) gave slightly discrepant magnitudes for Nova Persei. Comparing the magnitudes of these two stars with a number of those given in Table I., their magnitudes were determined to be 3·90 and 4·01 respectively. The magnitudes given in the Harvard Photometry for these stars are 4·00 and 3·95. The Radcliffe estimations agree more closely with the magnitudes given in the Revision of the Harvard Photometry, viz. 3·90 and 4·07.

Observers' Remarks on Colour of Nova and Comparison Stars.

March 8. Very red to the naked eye (R.)

March 16. In Ramsden 2¼-inch 42 is bluish-white, in strong contrast to Nova, very red. I should consider a comparison between these stars to be much affected by the diversity of colour. In Barclay "Finder" Nova is very red. In the 10-inch, using power 90, very red; and with 4-inch diaphragm over the object-glass also very red (W.) Nova in Barclay is very red (C.)

March 21. Marlborough 3·2-inch. Definition exceptionally good. 42 is bluish-white, difficult to compare with Nova. With Barclay, power 80, the Nova is red, but its colour seems to have a stronger yellow tinge than when last seen by me in this telescope (W.)

March 25. Nova very red to-night in Barclay (R.)

March 26. Nova red with yellowish tinge in 1¾-inch telescope (W.)

March 27. In Marlborough telescope Nova red and disc sharp with diffraction rings. 37 is also a red star, but not nearly so darkly tinted as the Nova. This redness may account for slight differences between naked-eye and telescopic views of the stars. In Barclay, with power 90, Nova very red; its red tint has increased since I last saw the star with this instrument. Sky misty and moonlight rather strong (W.) Very red in Barclay (R.)

March 28. Nova yellowish red in 1¾-inch telescope, power 20 (W.)

March 30. Barclay equatorial, power 45. I was much struck with the absence of colour in Nova (R.) The Nova is not nearly so red in the Barclay instrument as it was on March 16 (C.)

April 8. With 1¾-inch telescope and power 20. Nova is still red, with yellowish light in centre of image; 40 is bluish-white and 14 is white (W.)

April 10. Nova, in 1¾-inch telescope and using power 20, is red and 40 is yellow. In "Finder" of Barclay, Nova is very red and has a central yellow disc. With the 10-inch and power 90 this central yellow disc and the deep ruby-red flames around it are proportionately magnified (W.)

The observers were—Dr. Rambaut, indicated by A.A.R.
Mr. Wickham „ „ W.
Mr. Robinson „ „ R.
Mr. McClellan „ „ C.

Radcliffe Observatory, Oxford:
1901 *April* 11.

Note on Meridian Observations of Nova Persei.

By A. Graham, M.A.

(*Communicated by the Secretaries.*)

The position of *Nova Persei* as deduced from observations with the Cambridge Transit Circle was as follows :—

1901.	App. R.A. h m s	Mean R.A. Jan. 1. h m s	App. Decl. ° ′ ″	Mean Decl. Jan. 1. ° ′ ″
Feb. 25	3 24 29·882	3 24 28·222	43 34 3·85	43 33 54·25
28	29·524	27·934	4·08	54·74
Mar. 1	29·784	28·217	3·40	54·15
2	29·529	27·985	2·93	53·77
3	29·619	28·098	3·06	54·01
5	29·527	28·051	3·70	54·85
7	29·605	28·172	2·53	53·89
12	29·344	28·019	2·88	54·81
21	29·269	28·120	0·78	53·88
Apr. 1	29·114	28·107	43 33 59·59	54·29
	Mean $3^h\ 24^m\ 28^s·092 \pm {}^s·065$.		$43°\ 33'\ 54''·26 \pm {}''·27$.	

Notes.

February 25. Through clouds. Estimated 1st mag. February 28. Disturbed by knocking at Newall Dome. 2nd mag. March 1. Decidedly red. 2nd mag. March 2. Red. Unsteady. March 3. Through clouds. Faint. March 5. Red. March 7. Through clouds. Very faint. March 12. Considerably fainter. Somewhat less than 3rd mag. March 21. About 4th mag. March 25. Not visible on the meridian in a perfectly clear sky. April 1. Clouds. About 4·5 mag.

The Observatory, Cambridge.

Further Observations of the New Star in Perseus.

By A. Stanley Williams.

The following observations of the brightness of *Nova Persei* are in continuation of those already communicated to the Society and published in *Monthly Notices*, vol. lxi. p. 337. Down to March 18 they were made with the eye aided only by ordinary concave spectacles, but after that date an opera glass was employed. The provisional magnitudes in the last column are, as before, on the H.P. scale, and on the assumption that a step is equivalent to 0·1 mag. It appears to be actually rather smaller

than this, but the determination of the exact value is reserved until the completion of the observations.

Date. 1901.	Greenwich. M.T. h m	Observations.	Mag.
Mar. 5	6 55	*Nova* = β Persei + 5, δ Persei − 7	2·65
6	7 0	β Persei + 8, δ Persei − 4, γ Persei − 5	2·83
9	10 0	δ Persei + 2, γ Persei + 1, (ε Persei − 5)	3·3
12	10 30	δ Persei + 2, = γ Persei	3·25
18	9 50	δ Persei + 10, γ Persei + 9, ν Persei + 2, (ρ Persei − 2)	4·13
22	10 10	32 Persei + 5, 36 Persei − 3	5·22
25	9 15	32 Persei + 5, 36 Persei − 1	5·32
26	10 10	= κ Persei, ν Persei + 5	4·22
	11 45	κ Persei − 3, ν Persei + 4	4·02
27	10 20	κ Persei − 4, ν Persei + 5	4·02
28	11 0	κ Persei + 4	4 35
29	10 15	κ Persei − 2	3·75
31	10 0	κ Persei + 4 ±	4·35 ±
Apr. 1	10 0	= κ Persei, ν Persei + 6	4·27
4	10 5	κ Persei − 2, ν Persei + 5	4·12

Notes.

March 5. Very clear. March 6. Clear. March 9. Estimates perhaps not quite unaffected by cloud. March 12. Rather hazy; observations not satisfactory. March 18. Very clear. March 25. Very clear. March 26. Very clear. *Nova* distinctly brighter at $11^h\ 45^m$ than it was at $10^h\ 10^m$. March 27. Slightly hazy, sky very bright. March 28. Clear, but sky bright. March 29. Never quite free from thin cloud, but the *Nova* seemed uniformly a little plainer than κ *Persei*. March 31. Sky never free from thin cloud, but the *Nova* always seemed inferior to κ *Persei*. April 1. Moon very bright, but clear night. April 4. Moon full and sky very bright.

The relative brightness of the comparison stars has seemed in some cases to differ appreciably from what the H.P. values would imply. This is particularly the case with respect to κ and ν *Persei*. The H.P. makes the two stars about equally bright (κ 3·95 and ν 4·00), but on several nights in March ν has seemed to the writer not less than half a magnitude brighter than κ.*

A periodical variation in brightness of *Nova Persei* has recently been announced by von Glasenapp, of St. Petersburg, and Dunér, of Upsala (*A.N.* 3700), minima occurring on March 19,

* This difference may have been due, in part at any rate, to κ being at a slightly lower altitude than ν, and consequently more affected than the latter by atmospheric absorption and the greater brightness of the sky nearer the horizon. But on April 14 at $8^h\ 30^m$ in a very clear sky and with no Moon, κ still seemed distinctly fainter than ν, the difference amounting to three steps.

22, and 25. The above observations show well the faintness of the star on March 22 and 25, whilst there are less marked indications of a decreased brightness on March 28 and 31. It would seem from the latter that either there has been a real diminution in the amplitude of the variation, or else that the period is not exactly three days or uniform in length.

The following notes of the colour of the *Nova* were made with a $2\frac{3}{4}$-inch refractor. March 5, white, certainly no bluish or greenish tinge. March 12, white, with perhaps a slight reddish tinge. March 22, a distinct reddish tinge. March 26, white, with a slight reddish tinge. March 27, colour reddish, the reddish tinge more pronounced than it has been hitherto, though still not so deep and pronounced as the reddish colour of *Mars* or *Aldebaran* to the naked eye. March 28, colour reddish, not very deep. March 29, colour slightly reddish, not at all deep or pronounced. April 1, orange yellow, fairly deep. April 4, orange, not very deep.

It should be mentioned that the colour of this star has seemed to me particularly difficult to describe, there appearing to be distinct flashes of two or more different tints; also that the $2\frac{3}{4}$-inch refractor employed is over-corrected. With the same instrument and power *Algol* appeared distinctly bluish. The *Nova* has always shown a perfectly defined star disc whenever the seeing was good.

Hove: 1901 *March* 8.

Observations of Nova Persei. By M. C. Sharp.

Herewith I forward a table, giving estimated magnitudes of *Nova Persei*, for the most part made with the help of a binocular, except on March 6, 11, and 16, when only a brief glimpse with the naked eye was possible. On these three and some other nights, when moonlight and haze made comparisons difficult, the estimations are marked (?) Indeed, on nights when there was a slight haze or cloud the light of the *Nova* was much more affected than that of neighbouring stars, and in a small telescope it did not seem to have quite the same focus.

The colour at first was a bright orange yellow, as seen with a small refractor of 1·54 in. aperture, but got deeper as the brightness declined. Thus on March 9 and 10 it was pale orange, and a deep orange on the 25th, when it was at its then lowest observed magnitude, while on the 27th it had increased in brightness, and was a light orange yellow. On the 28th it was orange red, and orange yellow again on April 1, when the colour

was next observed. But on the 4th it was once more orange red. That night, however, was rather hazy.

	Est. Mag.		Est. Mag.
Feb. 28	1·6	March 25	5·2
March 1	2·2	27	3·9
3	2·3	28	4·7
6	2·8	30	4·3
9	3·4 (?)	31	4·3
10	3·3	April 1	4·7
11	3·6 (?)	4	4·5
16	3·8 (?)	8	4·7
23	3·8	10	5·3
24	4·1		

Highgate, N.: 1901 *April* 11.

Note on some Engraved Charts of Pogson's proposed Atlas of Variable Stars. By J. G. Hagen, S.J.

(*Communicated by the Secretaries.*)

In a former note in the *Monthly Notices* (1898, vol. lix., pp. 57–61) an account was given of Pogson's manuscripts, now preserved at the Harvard College Observatory, which comprise 134 catalogues and eighteen charts for as many variable or temporary stars. From these manuscript charts it was not clear whether they were meant as specimens for the engraver or as the final copies for reproduction. Since then Dr. R. Copeland informed me that the library of the Edinburgh Observatory possessed six engravings of charts which had been printed for Dr. Lee, of Hartwell House, where N. R. Pogson observed in 1859–60, and upon my request kindly forwarded them to me for examination.

The general aspect of these engravings is the same as that of the manuscript charts. They are of the same size, *viz.* about four inches in each dimension, not exactly square-shaped, but tapering, the meridians agreeing with conical projection and the parallels being straight lines. The co-ordinates are drawn at distances of 1^m and $10'$ respectively. The variable on each chart lies a little outside the central cross, because the co-ordinates are absolute, not differential. The epoch of the projection is known to be 1860 from the manuscript catalogues. The inscriptions are in substance the same as in the manuscripts. The star images are rather large, and in many cases accompanied by numbers, whose

meaning would be puzzling did we not know from another source that they are ten times the assumed magnitudes of the stars. The limit of these magnitudes was twelve in the earlier manuscripts, and thirteen in the later ones.

The upper inscriptions of these six engravings are as follows :—

(1) *Gemini*,	Var. 2,	now known as	2528	*R Geminorum.*
(2) *Cassiopeia*,	,, 2,	,,	8600	*R Cassiopeiæ.*
(3) *Ursa Major*,	,, 1,	,,	3825	*R Ursæ Majoris.*
(4) ,, ,,	,, 2,	,,	4557	*S* ,, ,,
(5) *Libra*	,, 1,	,,	5688	*R Libræ.*
(6) *Cygnus*	,, 3,	,,	7045	*R Cygni.*

Each chart bears below the marks :

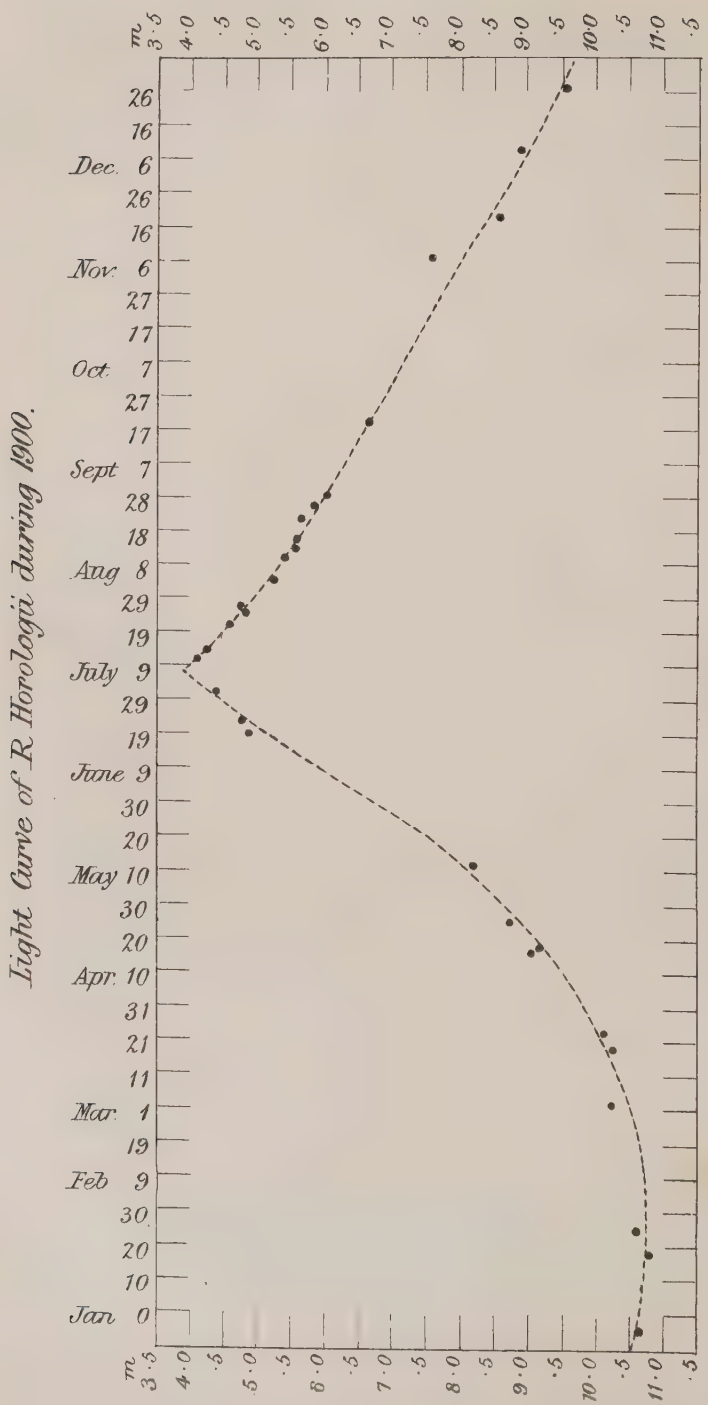
N. R. Pogson, Del. J. Basire, Sc.

The readers of this note will be interested to learn that three of these charts (Nos. 3, 4, 6) have actually been published, although not recognised as Pogson's charts. They are found in the volume lately issued under the title "Observations of Twenty-three Variable Stars," by the late George Knott, London, 1899 (*Mem. R.A.S.*, vol. lii.), on pages 150, 162, 204. These charts were probably Mr. Knott's own diagrams * and are perfect copies of Pogson's charts, with the exception of the appended notes. From Professor Turner's editorial notes we learn the meaning of those numbers, which might otherwise be taken as catalogue numbers—they are ten times the assumed magnitudes of the stars.

The same three charts, Nos. 3, 4, 6, and also No. 1, allow a comparison with the "Atlas Stellarum Variabilium," in which these same variables occur. The main difference will be found in the area of faintest stars, both as regards extension and density. This area is on Pogson's charts 80′ square, or seven times as large as in the atlas, and only half as dense. If we compare the areas of faint stars which are common to both kinds of charts, namely 30′ square, we find that

for *R Geminorum*,	out of	41	stars in the atlas,	Pogson has	22.	
R Ursæ Maj.	,,	23	,,	,,	,,	11.
S ,, ,,	,,	11	,,	,,	,,	8.
R Cygni	,,	40	,,	,,	,,	22.

* The charts 3, 4, 6 in "Observations of Twenty-three Variable Stars" were copied from Pogson's charts, impressions of which had been pasted by Mr. Knott in his ledgers of Variable Stars, now in the Library of the Royal Astronomical Society.—H. H. Turner.


Light Curve of R Horologii during 1900.
m
3·5
4·0
·5
5·0
·5
6·0
·5
7·0
·5
8·0
·5
9·0
·5
10·0
·5
11·0
·5
Dec. 6
Nov. 6
Oct. 7
Sept. 7
Aug. 8
July 9
June 9
May 10
Apr. 10
Mar. 1
Feb. 9
Jan 0
26
16
26
16
27
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17
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20
10

In the latter case, however, there are two of the twenty-two of Pogson's stars which are missing in the atlas. The comparison would be quite different for Series IV. (in which *R Cassiopeiæ* occurs) and Series V. of the atlas, which are adapted to variables of brighter minima. It was unfortunate in Pogson's plan of work that it comprehended an area as large as 80′ square for the faintest stars, and that it was applied indiscriminately to variables of bright and faint minima. As a reward for his untiring labour Mr. Pogson had deserved to see his work in print and bear fruit in the hands of others. It is to be hoped that this work may see the light yet in some shape and become useful to the science of variable stars.

Georgetown College Observatory:
1901 *March* 19.

Variation of R Horologii during 1900.

By Alex. W. Roberts, D.Sc.

The variation of this long-period variable during 1900 is so remarkable as to call for special notice.

As a rule the star at a maximum is slightly brighter than the 6th mag., but last year it reached the 4th mag. at its maximum phase.

In the accompanying plate (plate 11) is given the full light curve of the star as obtained from the observations made during 1900. The full period of the star is 408 days, but the portion of the curve on the plate demonstrates sufficiently the form of the light curve.

It will be seen from this curve that the light changes extend over seven magnitudes. This means that at its max. on 1900 July 10 *R Horologii* was at least 650 times brighter than it was at its minimum on 1900 February 2. It would be an advance of more than ordinary importance if we could determine how much hotter *R Horologii* was on 1900 July 10 as compared with 1900 February 2.

Indeed, one is convinced that the secret of long-period variation will be kept until some discovery is made which will enable us to deal with heat rays as we do with light rays.

Lovedale: 1901 *March* 13.

A Method of Mechanically Compensating the Rotation of the Field of a Siderostat. By H. C. Plummer, M.A.

1. The compensation of the rotation of the field of a siderostat, which is necessary for photographic purposes, can be effected doubtless in a great variety of ways. Three methods of achieving this object have been suggested by Professor Turner in the *Monthly Notices* for 1901 January. The third method is particularly elegant; but it is possible, I think, to go still further in the direction of mechanical simplicity. That this is the case I hope the device to be described in this note will make clear.

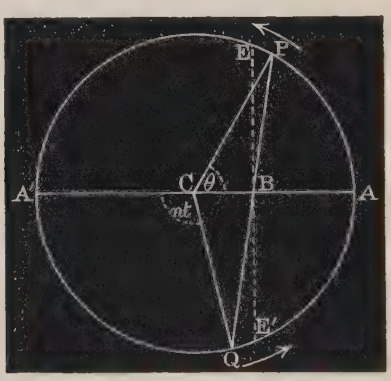


FIG. 1.

2. Let C be the centre of the circle $x^2+y^2=a^2$, and AA′ a diameter. If $ACP = \theta$ and $ACQ = \phi$ (fig. 1), both angles being measured in the same direction, the equation of PQ is

$$x \cos \tfrac{1}{2}(\theta+\phi)+y \sin \tfrac{1}{2}(\theta+\phi)= a \cos \tfrac{1}{2}(\theta-\phi).$$

Hence if PQ cuts AA′ in B, and $CB = b$

$$\frac{b}{a}=\frac{\cos \tfrac{1}{2}(\theta-\phi)}{\cos \tfrac{1}{2}(\theta+\phi)}=\frac{1+\tan \tfrac{1}{2}\theta \tan \tfrac{1}{2}\phi}{1-\tan \tfrac{1}{2}\theta \tan \tfrac{1}{2}\phi}$$

$$\therefore \tan \tfrac{1}{2}\theta \tan \tfrac{1}{2}\phi = -\frac{a-b}{a+b}$$

Let now $ACQ = \phi = \pi + nt$.

$$\therefore \tan \tfrac{1}{2}\theta = \frac{a-b}{a+b} \tan \tfrac{1}{2} nt = \mathrm{K} \tan \tfrac{1}{2} nt$$

if $\frac{b}{a}=\frac{1-\mathrm{K}}{1+\mathrm{K}}$. But the rotation which is to be compensated is given by the equation

$$\tan \tfrac{1}{2}\theta = \mathrm{K} \tan \tfrac{1}{2} nt$$

where $$K = \frac{\cos \frac{1}{2}(\rho+\delta)}{\cos \frac{1}{2}(\rho-\delta)} = \frac{1-\tan \frac{1}{2}\rho \tan \frac{1}{2}\delta}{1+\tan \frac{1}{2}\rho \tan \frac{1}{2}\delta}$$

or $$\frac{1-K}{1+K} = \tan \tfrac{1}{2}\rho \tan \tfrac{1}{2}\delta$$

Hence it is evident that if $b = a \tan \frac{1}{2}\rho \tan \frac{1}{2}\delta$, and if Q describes the circle uniformly in one day, P also describes the circle in one day, not uniformly, but with exactly the same motion as that of the field of a siderostat set for a star whose N.P.D. is δ. The angle ρ is the angle between the polar axis and the ray reflected in a fixed direction. If the siderostat mirror is placed south of the telescope, the rotation of the field will be in the same direction for all stars which are visible, and the limits of δ are 0 and $\pi-\rho$, and of $\tan \frac{1}{2}\rho \tan \frac{1}{2}\delta$ 0 and 1. That is to say, the limits of b are 0 and a, or B may have any position along the radius CA. The diameter AA′ is in the meridian of the instrument. When the star at the centre of the field is at upper culmination on the instrumental meridian PQ coincides with AA′, and is rotating with minimum velocity. When the same star comes to lower culmination PQ coincides with A′A, and is rotating with maximum velocity.

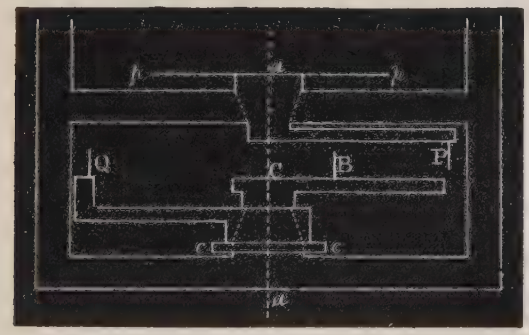


Fig. 2.

3. It is easy to imagine a mechanical arrangement which will satisfy these geometrical conditions. The points P and Q may be represented by two pins mounted on two arms of equal length which are capable of rotating about the same axis. A third bar perpendicular to this axis must be fixed in the meridian of the instrument, and on this we must have the means of accurately adjusting a third pin at a given distance from the axis. This pin serves to fix the position of the point B. A straight slotted bar is pivoted on the pin Q, and passing over the pins B and P keeps the three collinear. Then if the bar carrying Q rotates by clockwork with uniform diurnal motion, that carrying P rotates

in the required manner, and communicates the appropriate motion to the plate-carrier $p\,a\,p$ (fig. 2), to which it is attached. It is outside my province to discuss here the mechanical details by which the device suggested may best be practically realised. The section in the meridian plane is only given in the hope that it may make a little clearer the practicability of the general method. In this figure $c\,c$ represents the circle to which uniform motion is communicated, but the slotted bar QBP has been omitted.

4. Assuming that a practical design has been found, it is important to study the effect of inaccuracies of adjustment. In setting the pin B we may make an error δb in $b=a\tan\frac{1}{2}\rho\tan\frac{1}{2}\delta$. In the second place the motion may not be correct in phase, that is, the compensating bar PQ may cross the instrumental meridian a small interval of time δt in advance of the star at the centre of the field. When, therefore, the field has turned through an angle θ such that $\tan\frac{1}{2}\theta=\mathrm{K}\tan\frac{1}{2}nt$ the plate has turned through an angle $\theta+\delta\theta$ such that

$$\tan\tfrac{1}{2}(\theta+\delta\theta)=(\mathrm{K}+\delta\mathrm{K})\tan\tfrac{1}{2}n(t+\delta t)$$

$$\therefore\ \delta\theta=2\cos^2\tfrac{1}{2}\theta\{\delta\mathrm{K}\,.\tan\tfrac{1}{2}nt+\tfrac{1}{2}\mathrm{K}n\sec^2\tfrac{1}{2}nt\,.\,\delta t\}$$

$$=\sin\theta\,.\frac{\delta\mathrm{K}}{\mathrm{K}}+\frac{n}{\mathrm{K}}\cdot\frac{\mathrm{K}^2+\tan^2\frac{1}{2}\theta}{1+\tan^2\frac{1}{2}\theta}\,.\,\delta t$$

$$=\sin\delta\,.\frac{\delta\mathrm{K}}{\mathrm{K}}+\frac{n}{2\mathrm{K}}\{1+\mathrm{K}^2-(1-\mathrm{K}^2)\cos\theta\}\,.\,\delta t.$$

Now

$$\frac{\delta\mathrm{K}}{\mathrm{K}}=-\frac{\delta b}{a-b}-\frac{\delta b}{a+b}=-\frac{2a}{a^2-b^2}\,.\,\delta b$$

$$\tfrac{1}{2}\left(\frac{1}{\mathrm{K}}+\mathrm{K}\right)=\frac{a^2+b^2}{a^2-b^2}$$

$$\tfrac{1}{2}\left(\frac{1}{\mathrm{K}}-\mathrm{K}\right)=\frac{2ab}{a^2-b^2}$$

Hence

$$\dot{\theta}\theta=-\frac{2a\sin\theta}{a^2-b^2}\,.\,\delta b+\frac{n}{a^2-b^2}(a^2+b^2-2ab\cos\theta)\delta t.$$

5. The actual value of $\delta\theta$ is of little or no consequence, and only concerns the orientation of the picture on the plate. What is of importance is the rate of change of $\delta\theta$. This is

$$\frac{d}{dt}(\delta\theta)=-\frac{2a}{a^2-b^2}(\cos\theta\,.\,\delta b-b\sin\theta\,.\,n\delta t)\frac{d\theta}{dt}$$

$$=-\frac{2an}{(a^2-b^2)^2}(a^2+b^2-2ab\cos\theta)(\cos\theta\,.\,\delta b-b\sin\theta\,.\,n\delta t).$$

The critical values of this rate are given by

$$-(a^2+b^2-2ab\cos\theta)(\sin\theta\,.\,\delta b+b\cos\theta\,.\,n\delta t)$$
$$+2ab\sin\theta(\cos\theta\,.\,\delta b-b\sin\theta\,.\,n\delta t)=0$$

or $$-(a^2+b^2)(\sin\theta\,.\,\delta b+b\cos\theta\,.\,n\delta t)$$
$$+2ab(\sin 2\theta\,.\,\delta b+b\cos 2\theta\,.\,n\delta t)=0$$

i.e. $$(a^2+b^2)\sin(\theta+\alpha)=2ab\sin(2\theta+\alpha)$$

if $$\tan\alpha=b\,.\,n\delta t/\delta b$$

If the motion of the arm which carries the pin Q is obtained by gearing it to the hour circle of the siderostat the adjustment of the phase will be automatic. This would be a most convenient arrangement, and ought to minimise the error to be feared from this source. When $\delta t=0$ the critical values of the rate found above will occur at the positions

$$\theta=0,\ \pi,\ \pm\cos^{-1}\frac{a^2+b^2}{4ab}.$$

In one complete rotation the two errors of adjustment will cause a simple oscillation of the field with respect to the plate, of which the amplitude is

$$\frac{4a}{a^2-b^2}\left\{[\delta b]^2+b^2[n\delta t]^2\right\}^{\frac{1}{2}}$$
$$=\frac{2\sin\rho\sin\delta}{\cos\rho+\cos\delta}\left\{\left[\frac{\delta b}{b}\right]^2+[n\delta t]^2\right\}^{\frac{1}{2}}$$
$$=\frac{2\sin\rho}{\cos\rho+\cos\delta}\left\{[\Delta\delta]^2+\sin^2\delta[n\delta t]^2\right\}^{\frac{1}{2}}$$

where $\Delta\delta$ is the error in δ corresponding to the error δb in b. For since $b=a\tan\frac{1}{2}\rho\tan\frac{1}{2}\delta$

$$\delta b/b=\Delta\delta/\sin\delta$$

The fixed bar which carries the pin B will naturally be graduated so as to give the reading of δ directly.

6. When $\delta+\rho=\pi$, $K=0$, and $b=a$; that is to say, in the limit B coincides with A. If the telescope is due north of the siderostat, $\delta+\rho=\pi$ only for a star which culminates on the southern horizon. In the case of a cœlostat the condition is permanent. The representation of the motion of the field given in § 2 illustrates very well Professor Turner's remark on this case. For let EE′ (fig. 1) be the chord perpendicular to the diameter AA′, then P describes the arc E′AE while Q describes the arc EA′E′, and the arc EA′E′ while Q describes E′AE. Now in the limit the arc E′AE vanishes when B coincides with A, and the arc EA′E′ approaches the whole circumference. Hence we see that P coincides with A for twenty-four hours, and then describes the circle with infinite velocity.

7. This interesting example of a change of sign in passing through an infinite value may be considered in another way. We have

$$\frac{d\theta}{dt}=\frac{n}{a^2-b^2}(a^2+b^2-2ab\cos\theta)$$
$$=\frac{n}{2K}\{1+K^2-(1-K^2)\cos\theta\}$$

Hence the hodograph (turned through 90°) of a point rotating with the field may be represented on a scale proportional to K by the curve

$$r=1+K^2-(1-K^2)\cos\theta$$

which is, of course, a limaçon. Since $1-K^2<1+K^2$, the curve has no node. The vector in the direction $\theta=\pi$ is constant for all values of K. When $K=1$, the curve is a circle concentric with the pole. When $K=0$ the hodograph is a cardioide with a cusp at the pole. The parameter is finite, and this evidently corresponds to an infinite angular velocity, because the hodograph has been drawn on a scale proportional to K. In this way we see, not only that the velocity is infinite, but that it is proportional at every point to the radius vector of a cardioide drawn in the same direction.

8. It may not be out of place to add some indication of the way in which this simple device suggested itself. Consider two points describing circles whose radii are r and s, the first with the motion characteristic of the siderostat field, the second uniformly in the same period. Let the motions be projected on a diameter of each circle and let x and y be the projections of the moving radii, so that

$$x=r\cos\theta,\ y=s\cos nt$$

$$\therefore\ \tan^2\tfrac{1}{2}\theta=\frac{r-x}{r+x},\ \tan^2\tfrac{1}{2}nt=\frac{s-y}{s+y}$$

$$\therefore\ (r-x)(s+y)=K^2(s-y)(r+x)$$

$$\therefore\ xy(1-K^2)+sx(1+K^2)-ry(1+K^2)-rs(1-K^2)=0$$

Hence, if the circles are concentric and the diameters of projection coincident, x and y determine two ranges which are related homographically. If further $s=r$ and the sign of y is changed, the relation becomes

$$xy(1-K^2)-rx(1+K^2)-ry(1+K^2)+r^2(1-K^2)=0$$

or

$$\left(\frac{x}{r}-\frac{1+K^2}{1-K^2}\right)\left(\frac{y}{r}-\frac{1+K^2}{1-K^2}\right)=\frac{4K^2}{(1-K^2)^2}$$

and the ranges are in involution. The centre of the involution is at a distance $r(1+K^2)/(1-K^2)$ from the centre of the circle and the extremities of the diameter of projection are conjugate points. Hence the construction (fig. 3): Let PMP', QNQ' be chords of a circle which are constrained to remain perpendicular to the diameter AA'. The centre of the circle is C, and $CO=r(1+K^2)/(1-K^2)$. Let OMNHK be a Peaucellier linkage, such that AA' are possible positions of MN. Then if Q describes the circle uniformly in twenty-four hours in the sense

indicated, P will move in the manner required to compensate the rotation of the siderostat field.

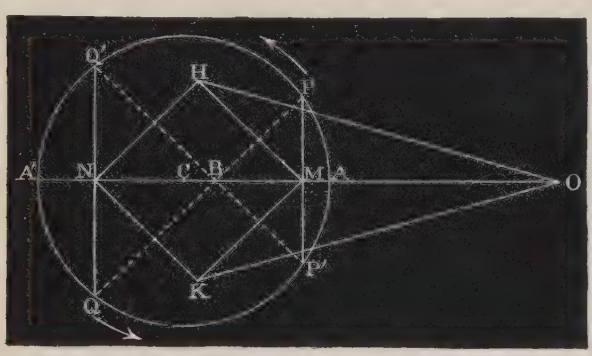


Fig. 3.

9. So far we have derived the motion of P from the rectilinear motions of M and N. The motion of N being simple harmonic, that of M may perhaps be called simple involutional. The method is not a practical one because for fields in the neighbourhood of the pole O is at a very great distance from C. But this method is directly related to the vastly simpler one already given. The parallel chords PP′ and QQ′ are conjugate lines of an involution pencil of which the vertex is at infinity, and the tangents at AA′ are also a conjugate pair. Let PQ, P′Q′ intersect AA′ in the point B. By Desargue's theorem every line intersects the circle and opposite sides of the inscribed quadrangle PP′ QQ′ in an involution range. Hence B is a double point of the involution of which AA′, MN are pairs, and it follows that B is a fixed point for every pair of the involution pencil. Its position is given by the equation

$$x^2(1-K^2)-2rx(1+K^2)+r^2(1-K^2)=0$$

of which the roots are $x=\frac{1-K}{1+K}$ and $x=\frac{1+K}{1-K}$. The former lies within the circle, and is the position determined independently in § 2. The latter is the double point outside, and does not give so convenient a solution of the practical problem. The points PQ, P′Q′, ... are pairs of an involution range in the circle. This proposition, of which a proof has been given here, can be stated in a more general form. An involution pencil, of which the tangents from the vertex to a conic form a pair, determines an involution range on the conic.

Oxford: 1901 *April* 2.

Further Investigation of the "Two Method" Personal Equation. By Walter W. Bryant.

In a former paper (*Monthly Notices*, 1898 March) I gave an analysis of the results of five years' determinations of the differences of personality between the eye-and-ear and galvanic method for H., A. C., and B., whenever a clock-star was observed by either of them both ways the same night, as part of the routine of the observatory at Greenwich.

The additional evidence since accumulated may throw fresh light upon some of the points then raised.

It may be well to note briefly, as before, that the quantity under discussion is very fairly represented by $t_h + t_c$ for H., who observes galvanically by the "sensorial" method, and by t_h for A. C. and B., who adopt the "muscular" method, t_h being the "reaction to sound," and t_c the time occupied in making a contact, which is theoretically eliminated in the "muscular" method.

Some of the more ordinary causes of variation may be classified as follows :—

A. Personal, the observer's physical, and especially nervous, condition with regard to—

(1) General health, age, &c.

(2) Time of year, time of day, temperature and other external influences.

(3) Comfort at the moment, depending upon observing position (standing, sitting, or reclining), including the inclination of the head with reference to the clock, &c., &c.

B. Impersonal, depending on instruments.

(1) The pricker chronograph is open to the objection that the slight tendency to stop the barrel may introduce a variation in the accuracy of the clock comparison depending upon the fraction of a second between the beats from the two clocks.

(2) Galvanic circuits are liable to vary in resistance, especially at contacts, with heat, cold, damp, &c. ; but this cause is probably insignificant.

(3) From a cause possibly connected with (1) the seconds of Clock Hardy, the transit clock, do not appear to be of the same length, the odd seconds giving a reading differing from that of the even ones.

(4) The force necessary to make a contact varies with the strength of the spring. A new spring tends to make all galvanic observations a little late. If this is delicately adjusted to avoid the difficulty it is found that some

observers make involuntary contacts, which is a far greater evil.

C. Impersonal, depending on—

(1) Optical conditions, brightness of sky, fineness of definition, &c.; also wind, which may affect t_h.

(2) Stellar magnitude, which, however, in the case of clock stars, is not supposed to be so important as for fainter stars.

There is also at times a gratuitous error introduced if the clock comparison is not automatic, which is liable to cancel if not more than cancel t_h, since the dead-beat escapement is not adapted for the "muscular" method of observation (see previous paper for other notes on observing clock).

In the present paper I am only concerned with the effects of A, though C is implicitly involved in A (2).

A (1). One would expect that, as a young observer gains experience, if he adopts the "muscular method" for galvanic observations, his "two-method" P.E. will tend to diminish. But as the effect of age is probably, after a certain time, to slacken mental processes, it seems probable that there is a limit to this diminution, and that at a later period the P.E. will increase.

N.B.—In all that follows suffixes stand for number of single stars observed, and times are given as they were actually observed. I have not reduced any of them to the equator, since neither t_h nor t_c is a function of arc, but only of time, and t_s, the "reaction to light," does not appear in the "two-method" P.E. I have also refrained from loading the observations with varying figures for probable error. Those I have determined vary from $\pm^{s}\cdot04$ to $\pm^{s}\cdot08$ approximately for a well-determined group, but are naturally greater for poor determinations.

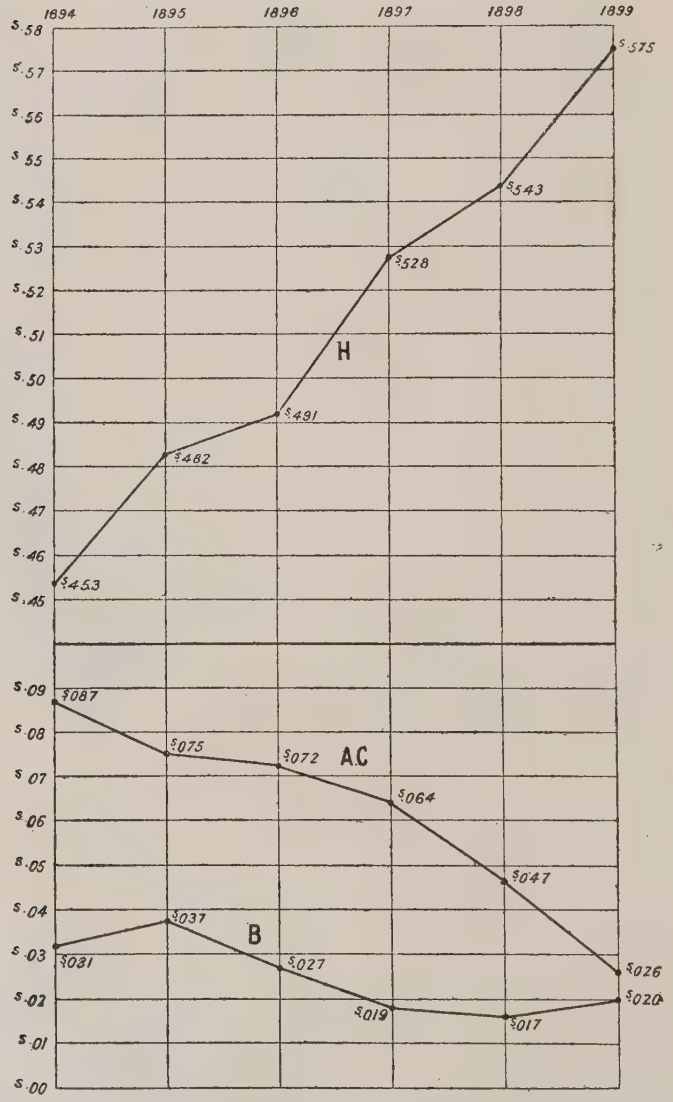
The first table shows annual variation only.

	1893. s	1894. s	1895. s	1896. s	1897. s	1898. s	1899. s	1900. s
H.	$+\cdot44_{178}$	$+\cdot48_{140}$	$+\cdot43_{880}$	$+\cdot52_{739}$	$+\cdot50_{845}$	$+\cdot54_{932}$	$+\cdot57_{228}$	$+\cdot60_{333}$
A.C.	$+\cdot10_{769}$	$+\cdot09_{324}$	$+\cdot06_{222}$	$+\cdot07_{117}$	$+\cdot08_{225}$	$+\cdot04_{037}$	$+\cdot01_{872}$	$+\cdot01_{963}$
B.	$-\cdot00_{4196}$	$+\cdot05_{6109}$	$+\cdot04_{0124}$	$+\cdot01_{6141}$	$+\cdot02_{585}$	$+\cdot01_{5154}$	$+\cdot01_{2180}$	$+\cdot03_{4196}$

If we smooth the above by taking means of three consecutive years, the result is striking.

It is unfortunate that the curve for H. cannot be traced back, neither A.C. nor B. having yet reached the standing of H. at the beginning of the series of observations. I am not sure whether to expect a minimum for the "sensorial" method, but if so H. appears to have passed it. In a few years' time the curves for A.C. and B. ought to give a fair test to my experimental theory. B. seems to be inclined to turn back already, but that may be accidental (a new spring, see above, B (4), was fitted in 1900).

It must be remembered in connection with H.'s curve that he is not a "muscular" observer, and so the ascent of the curve may

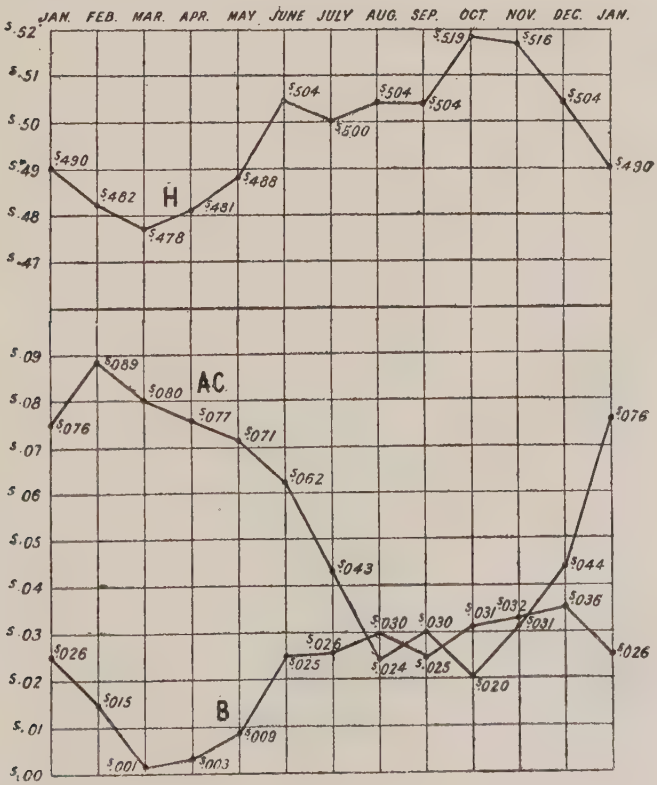


have some other explanation apart from the one suggested above.

A (2). As regards time of year.

	H.	A.C.	B.
	s	s	s
January	+ ·493$_{22}$	+ ·087$_{19}$	+ ·02988
February	+ ·470$_{29}$	+ ·095$_{20}$	+ ·011$_{84}$
March	+ ·483$_{39}$	+ ·086$_{38}$	+ ·006$_{112}$
April	+ ·481$_{40}$	+ ·058$_{38}$	− ·014$_{80}$
May	+ ·478$_{49}$	+ ·087$_{39}$	+ ·018$_{120}$
June	+ ·504$_{38}$	+ ·068$_{24}$	+ ·024$_{80}$
July	+ ·530$_{28}$	+ ·032$_{19}$	+ ·033$_{43}$
August	+ ·467$_{27}$	+ ·030$_{24}$	+ ·021$_{123}$
September	+ ·516$_{24}$	+ ·011$_{39}$	+ ·035$_{122}$
October	+ ·529$_{31}$	+ ·048$_{26}$	+ ·019$_{137}$
November	+ ·511$_{24}$	+ ·001$_{19}$	+ ·040$_{121}$
December	+ ·508$_{14}$	+ ·045$_{23}$	+ ·038$_{83}$

Smoothing as before, three months at a time, we obtain the following results :—



Within limits the curves for H. and B. are similar, with a well-marked minimum in the spring, a maximum towards the end of the year, and a straight piece in the summer.

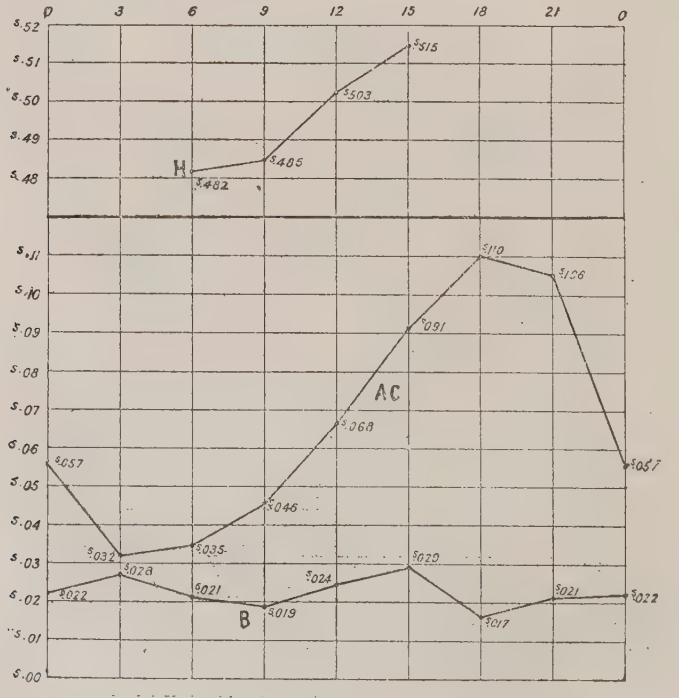
A.C., on the other hand, has a strong minimum in the autumn and a maximum at the beginning of the year.

It is not immediately clear what can be made of these results, but they are interesting even if the weights of the observations are too low to encourage theorising.

Next as regards time of day. Three hour groups.

G.M.T.	H.	A.C.	B.
h	s	s	s
0	—	$+\cdot 058_5$	$+\cdot 057_9$
3	$+\cdot 510_2$	$+\cdot 025_{11}$	$+\cdot 028_{87}$
6	$+\cdot 454_{41}$	$+\cdot 027_{50}$	$+\cdot 014_{298}$
9	$+\cdot 496_{134}$	$+\cdot 054_{126}$	$+\cdot 020_{319}$
12	$+\cdot 506_{164}$	$+\cdot 058_{103}$	$+\cdot 024_{230}$
15	$+\cdot 507_{23}$	$+\cdot 093_{18}$	$+\cdot 027_{38}$
18	$+\cdot 531_{14}$	$+\cdot 123_{12}$	$+\cdot 037_{80}$
21	—	$+\cdot 120_{1}$	$-\cdot 012_{26}$

All three show a similar effect, possibly due to fatigue, between 6^h and 15^h.



Beyond that there is not the same meaning to the curve, as observations at 18^h indicate, not a long duty, but a short special one, denoting Moon about third quarter.

A (3). Dividing the stars into groups of 10° N.P.D.

N.P.D.	H.	A.C.	B.
°	s	s	s
51–61	+·488$_{26}$	+·040$_{37}$	+·010$_{98}$
61–71	+·473$_{90}$	+·055$_{75}$	+·031$_{231}$
71–81	+·481$_{75}$	+·073$_{67}$	+·020$_{280}$
81–91	+·508$_{113}$	+·049$_{82}$	+·027$_{274}$
91–101	+·498$_{41}$	+·035$_{39}$	+·016$_{173}$
101–111	+·547$_{28}$	+·071$_{16}$	+·013$_{94}$
111–121	+·503$_{8}$	+·092$_{10}$	+·013$_{40}$

Here the first three groups correspond fairly well with stars observed in more or less recumbent, and the last three in practically upright position, though for about the middle group, and for five or six degrees each side of it, stars may be observed also kneeling, sitting, or stooping.

A smoothed curve seems therefore out of place, and a rigid line for attitude cannot be drawn either, so that I think the figures should be left to speak for themselves, with the note that ^{s}·003 is greater than the maximum effect of change of distance from observing clock, so that that will not of itself account for the great increase in H. for low stars, and still less will it account for B.'s results. I have investigated the latter more closely for groups of five degrees, three degrees, and one degree (as well as for single hours of G.M.T. in the previous table), and though the results seem too cumbersome and undecided to be worthy of insertion here I may mention that there is a marked maximum at about 70° N.P.D., and that the smallest values appear to belong to the high stars and those below the equator, so that I should conclude that the erect position is the best, but that as the angle of inclination of the head to the direction of the sound of the clock varies, there is a critical angle between the vertical and horizontal, for which the reaction to sound is slowest. An analogous idea was presented to the society by A. W. Roberts as the result of his photometric observations, *i.e.* that there is a critical angle for the sight, two equal sources of light not appearing equal in all positions of the observer.

It seems to me that the part of A (1) which is beyond ordinary investigation, viz. the uncertain condition of the observer's nervous system (or digestion), rendering extended comparisons misleading, is the difficulty which tends most to weaken these results. A long series of experimental observations of this kind is out of the question at Greenwich, the transit circle having a vast amount of work to do, of which these comparisons form but one small item.

Nevertheless I hope in a few years' time to be able to extend this investigation a little further, and to open up one or two fresh lines of research in this psychologically interesting field.

Anomalous Occultations of Stars by the Moon. By R. T. A. Innes.

It is well known that on several occasions double stars have been discovered through the phenomena attending their occultation by the moon.

Cases in point are the discovery by Professor Barnard in 1883 of the duplicity of Bradley 2607, the star which is closely preceding β *Capricorni*, and the discovery by Burg of Vienna in 1819 that *Antares* is a double star.

Another remarkable instance, but not so well known, is that of P. XVI. 68. On 1836 September 16 Sir Thomas Maclear, using a 3-inch telescope, observed the occultation of this star, and remarked that the star "disappeared gradually."

Fifty-three years later Burnham, with the 36-inch Lick refractor, found this to be a double star (β 1115).

In my own experience unusual occultations of many stars h e been observed, and some of these were afterwards found to be known pairs, viz.

BD. −22°, 3908. "Glided out, took $0{\cdot}5^s$ to disappear." This is β 809, mags. 8·6 and 10·2, distance $1{\cdot}6''$.

P. XIII. 126. "Began to fade at $25{\cdot}7^s$, disappeared at $28{\cdot}0^s$, good." This is β 932, $0{\cdot}44''$.

The slow progression of the moon amongst the stars (about $0{\cdot}55''$ in one second of time) and the sharp character of a good disappearance at the dark limb should similarly disclose the presence of double stars of exceeding closeness, or of stars having a measurable diameter. The greater number of dark-limb occultations are seemingly instantaneous; the exceptions are of two classes:

(A) The star disappears in two distinct stages.

(B) The star disappears gradually, or glides.

When a star disappears in two distinct stages, there is a high presumption that it is really a double star; and at first sight it would appear that the phenomena of "gliding" occurs when a star has a disc of such a size that it is not instantaneously obliterated by the advancing moon. But "gliding" is actually found to occur with double stars, as is shown in the cases of β 809, β 932, and β 1115 quoted above. It may there-

fore be that the difference between "disappearing in two stages" and "gliding" is due to physiological causes. The examples just referred to show that in one case I failed to discriminate between a disappearance in two stages, half a second apart (which is what must actually have occurred) and a "glide"; in the other case the two stages took $2{\cdot}3^s$, and yet they were not seen distinctly, as the word "fade" was adopted. Thus it remains doubtful if there is any real distinction between a star disappearing behind the moon's limb in two stages or in "gliding." If a star has an appreciable diameter it will appear to go out gradually, if the whole time occupied in completing its obscuration is upwards of about $\frac{1}{10}$th of a second. The limit of persistency of retinal impressions is given as from only $\frac{1}{50}$th to $\frac{1}{30}$th of a second—a determination based, I believe, on experiments with electric sparks. In the case of stars it is probable that the limit is longer—perhaps $\frac{1}{10}$th of a second—as has just been assumed. If a star of the ninth magnitude disappears behind the so-called dark limb when the moon is three or four days old, the phenomenon is seldom seen as a sudden one. This may be attributed to the lack of contrast between the star and the strongly illuminated dark limb of the moon, so that the star is only glimpsed by special effort—an effort that cannot be continuously maintained—the interruptions of vision lasting perhaps $\frac{1}{5}$th of a second. If *Sirius* has a real diameter of $0{\cdot}01''$ its complete occultation would occur in $0{\cdot}02^s$, which would certainly be called "instantaneous." This assumes that the occultation is central. If it occurs at an angle θ from the direction of the moon's path, the time would be

$$\frac{0{\cdot}02^s}{\cos\theta};$$

and this only amounts to $0{\cdot}1^s$ for the few occultations (1 in 50), where θ is greater than 78°. When θ becomes greater, irregularities of the moon's limb nullify a rigorous application of the formula. It is not probable that any star in the zodiac or elsewhere exceeds *Sirius* in apparent diameter, but it is not impossible. Sometimes, when searching for double stars, one comes across a solitary star which refuses to exhibit the satisfactory hard disc of a single star, but which has not the characteristics of a close double star; there is just a chance that in these rare cases an appreciable disc is really seen. Again, planetary and gaseous nebulæ vary in size from measurable diameters to $1''$ or less, and they no doubt exist in increasing numbers as they become smaller. The star *Lalande* 20204 is really a planetary nebula, but it has often been observed as a star. Another planetary nebula is C.P.D. $-45°$, 7306, and is according to Sir J. Herschel "perfectly sharp, $4''$ in diameter." It is, however, unlikely that there are many unrecorded nebulæ in the guise of bright stars, as gaseous nebulæ are so easily discovered with the spectroscope.

It would thus appear that both the phenomena of disappearing in two stages and of gliding are almost certainly due to the star being really a binary system, but not incontestably so. It is necessary to add that "gliding" is not due to an unsteady atmosphere, as I have frequently secured instantaneous occultations with the very worst definition.

This paper owes its origin to the vivid impression made on my mind when the occultation of *o Tauri* was observed some nights ago (February 26) with the 7-inch Merz refractor of the Cape Observatory. The star disappeared in two equal parts separated by about $0{\cdot}2^s$. The phenomenon was so distinct that I feel quite sure that this star is double. It is difficult to be exact as to the interval of time, which might easily be greater or less than $0{\cdot}2^s$. If it is approximately correct, and the position angle of the double star happens to be parallel to the moon's path, the distance would be about $0{\cdot}1''$. A somewhat similar case with the star τ_1 *Arietis*, wherein two observers at separate stations took part, is recorded in the *B. A. A. Journal*, vol. iii. p. 187.

In the recent lists of Cape occultations published by Sir David Gill many anomalous occultations are recorded; some of the more noticeable which I have observed are:

o Tauri.	As mentioned above.
θ Cancri.	"Disappeared in two stages 0·2 sec. apart as though double, not glided" (1898 April 28).
BD. 15°, 1975.	Mag. 8·0, not so faint as given in B.D., "glided, taking quite 1 sec. to disappear" (1898 May 26).
P. XIV. 212.	A well-known double star with considerable parallax and proper motion. (See *Cape Annals*, vol. viii. p. 105, B.) "The pr. and fainter star glided, the other star disappeared normally" (1898 August 23).
β 709.	"The first and brighter star glided" (1898 December 18).
P. III. 128.	"Some light seemed to disappear some 2 or 3 secs. before the occultation" (1901 January 28).
Arg. + 21°, 526.	"Glided" (Marked "dpl. ?" in *A.G.C.*) (1900 March 6).
δ Scorpii.	"Glided, took $0{\cdot}4^s$ to disappear" (1899 July 18).
P. XI. 77.	"Glided, $0{\cdot}3^s$, greater part of light disappeared suddenly" (1899 May 19).
132 *Tauri.*	"Disappeared in two portions $0{\cdot}1^s$ between, very good observation" (1899 May 12).

A considerable number of the double stars disclosed by occultations will be too close to be confirmed by the telescope, and will therefore form a class intermediate to the visual double and the spectroscopic binary.

The occultations of any spectroscopic binaries within the zodiac should be watched for and widely observed.

A series of occultations of *α Virginis* is now commencing. As *α Virginis* is a well-known spectroscopic binary, these occultations demand special attention.

A point in favour of occultations is that they can be observed very well indeed with telescopes of moderate size.

On some future occasion it is purposed to make a collection of all occultations of the above classes that have been recorded.

Cape of Good Hope: 1901 March 5.

Meteoric Showers from the Region of α–β Persei and η Aurigæ.

By W. F. Denning.

A very brilliant meteor was observed at various places in the south of England on 1901 March 6, $7^h\ 25^m$. Descriptions of its appearance and path have been received from Denmead, Hants; Clapham Common, London, and Epsom Common; Isle of Wight; Lewes, Torquay, Yeovil, &c. Several of the observers give the direction of flight as straight from *Nova Persei*, and there is no doubt that the radiant point was at or closely contiguous to $51°+43°$. There is a well-known, long-enduring shower from about 2° W. of this point, and it forms No. XLIII. in the "General Catalogue of Radiants" (*Memoirs R.A.S.*, vol. liii.). At Denmead, Hants, the meteor as it passed under *Orion's* belt appeared like a ball of fire, and from it three small fragments were detached, one being greenish and two, close together, bright red. At Lewes the meteor is described as being magnificently brilliant and of a greenish colour. "It emerged midway between the *Pleiades* and constellation *Perseus*, and after describing a parabola towards the W. it disappeared, leaving a fiery train in its wake." Miss L. M. Milner, of Torquay, says the meteor was directed straight from the new star and fell towards E. through the constellations of *Lynx* and *Leo*. It was orange colour at first, but developed into a brilliant green; then burst into separate green particles and died out. At Yeovil the meteor was seen in *Gemini*, and passed almost vertically downwards. A comparison of the various observations shows that the object fell from about eighty-four to twenty-seven miles above the English Channel fifteen miles south of St. Alban's Head, Dorset, and

St. Catherine's Point, Isle of Wight. The motion was slow, from W. to E., along a path of about sixty-six miles, but these results are only approximate.

A fireball which brilliantly illuminated the sky at several places was seen at Slough, Plymouth, Leicester, &c., on 1900 November 27 $11^h\ 10^m$. At the former place Professor A. S. Herschel recorded the apparent path as from $338°+12°$ to $328°+2°$, and the motion was very slow. The radiant point was at about $47°+45°$, and in nearly the same position as that of the fireball of March 6 previously referred to. The height was from fifty-seven to seventeen miles over Ilfracombe and the Bristol Channel.

On 1899 September 2 $12^h\ 5^m$ a meteor brighter than *Venus* was seen by the writer at Bristol and by Mr. Ivo F. H. C. Gregg at Malvern. The radiant from the pair of observations was at $46°+42°$, and the height of the object eighty-six to sixty miles over Shipston and Tewkesbury, Gloucestershire.

Several other very fine meteors—notably those of 1896 April 12 $8^h\ 6^m$ and 1894 April 22 $7^h\ 36^m$—have diverged from the same position, and Professor Herschel found the radiant of a shooting star recorded on 1865 November 12 at $50°+42°$. Including the latter with seven of my own determinations from duplicate or multiple observations of individual meteors, we have the following list :—

Date.			α	δ	
1901	March	6	$51°$	$+43°$	Fireball.
1896	April	12	50	+42	,,
1894		22	48	+44	,,
1895	Aug.	7	45	+47	Shooting star.
1899		14	52	+46	,,
1899	Sept.	2	46	+42	Fireball.
1865	Nov.	12	50	+42	Shooting star.
1900		27	47	+45	Fireball.

The mean of these positions is at $48\frac{1}{2}°+44°$.

A brilliant meteor seen at Bristol and Cooper's Hill, Kent, on 1875 March 9, was apparently from the same radiant.

There is a well-defined and tolerably rich shower, or succession of showers, from this centre during the last six months of the year. I have frequently recognised it during the last twenty-five years, and have secured the following independent values for the radiant :—

Date.	α	δ	Meteors.	
	°	°		
1876–87 Feb. 23–Mar. 12	47	+45	5	V. S.
1877 July 20	47	+45	5	R. K.
1884 23–25	48	+43	15	R. K.
1886 Aug. 2–10	48	+43	10	R. K.
1877 3–16	46	+45	6	R. K.
1888–96 5–14	48	+44	6	R. K.
1893 8–16	48	+44	11	R. K.
1899 13–17	47	+44	6	R. K.
1884 19–21	46	+44	4	R. K.
1879 21–23	46	+47	9	R. K.
1900 24–Sept. 2	46	+43	5	R. K.
1887 30	46	+43	4	R. K.
1885 Sept. 15	48	+44	6	R. K.
1877 15–16	47	+45	7	R. K.
1886 22–30	48	+44	6	R. K.
1877 Oct. 3–13	46	+45	14	R.
1887 17–24	47	+44	6	R.
1879 20	45	+46	6	R.
1900 23–27	47	+43	6	S.
1874–99 Nov. 10–15	48	+43	10	S.
1876–87 27–Dec. 8	48	+42	10	S.
1874–88 Dec. 28–Jan. 11	47	+44	7	V. S.

Abbreviations in last column are R. rapid, S. slow, K. streak, V. very.

The average position from the twenty-two radiants is at 47·0° + 44·1°, which presents a satisfactory agreement with that derived from the eight doubly observed meteors before alluded to. I believe that, allowing for precession and giving extra weight to the most accurate observations, the centre of radiation of this stream is as nearly as possible $48° + 43\frac{1}{2}°$.

During the thirty-three nights from July 16 to August 17 in various years since 1875 I have recorded sixty-six meteors from this shower, and have seen many others the paths of which were not registered. In July, August, and September the flights are rapid and usually marked with streaks; in October the motion is less rapid, and the streaks are absent. In November and succeeding winter months the meteors travel slowly, and sometimes very slowly, with trains.

The position of the radiant closely W. of *Nova Persei* is interesting, apart from the fact that it has furnished several recent fireballs, and that the shower is apparently one having a very extended duration.

About 20° E. there is another similar radiant (G. C. lxv.) at the star *η Aurigæ* (74°+41°). Professor Herschel and several other observers saw a fine meteor from this centre on 1901 February 13, falling from fifty-six to twenty-six miles over Pembrokeshire. The same apparent radiant gave us the brilliant fireball of 1896 September 10. During the months August to December in various years I noticed this stream on many occasions, and having arranged the observations into groups and reprojected all the paths, find the following radiants :—

Date.	Night.	Radiant. α δ	
Aug. 7–22	16	73°+41°	16 meteors.
Sept. 12–22	11	74+42	28 ,,
26–Oct. 2	7	73+41	15 ,,
Oct. 13–25	13	74+41	10 ,,
31–Nov. 17	18	73+42	15 ,,
Nov. 28–Dec. 13	16	74+41	10 ,,

The shower is also a conspicuous one, and often yields brilliant fireballs between about February 5–15, though I have myself seen but little of it at that period, having made very few observations in the month of February. From Zezioli's and a number of other meteor-paths observed in Italy in 1869–72 I found a good radiant at 74°+43° (twenty-two meteors) for February 5–10. Greg and Herschel give a radiant at 73°+40° for February 9–17. Schiaparelli found one at 74°+48° from Zezioli's observations on 1868 February 16, and Heis gave 80°+40°, February 16–28. For March 9–27 Greg derived a radiant at 74°+47° from Zezioli's meteors, while on 1865 April 29 Professor Herschel found the radiant of a doubly observed fireball at 75°+47°. This shower of *Aurigids* and that of the *α–β Perseids* deserve special notice on account of their persistency or frequent repetition, and for the very brilliant fireballs which they occasionally discharge. And it is a curious circumstance that the latter sometimes make their apparitions at times when there are few, if any, ordinary shooting stars emanating from the same radiants.

Bishopston, Bristol :
1901 *March* 24.